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METHOD OF AND APPARATUS FOR PRODUCING CONTINUOUS REFRIGERATION

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Fig 1.

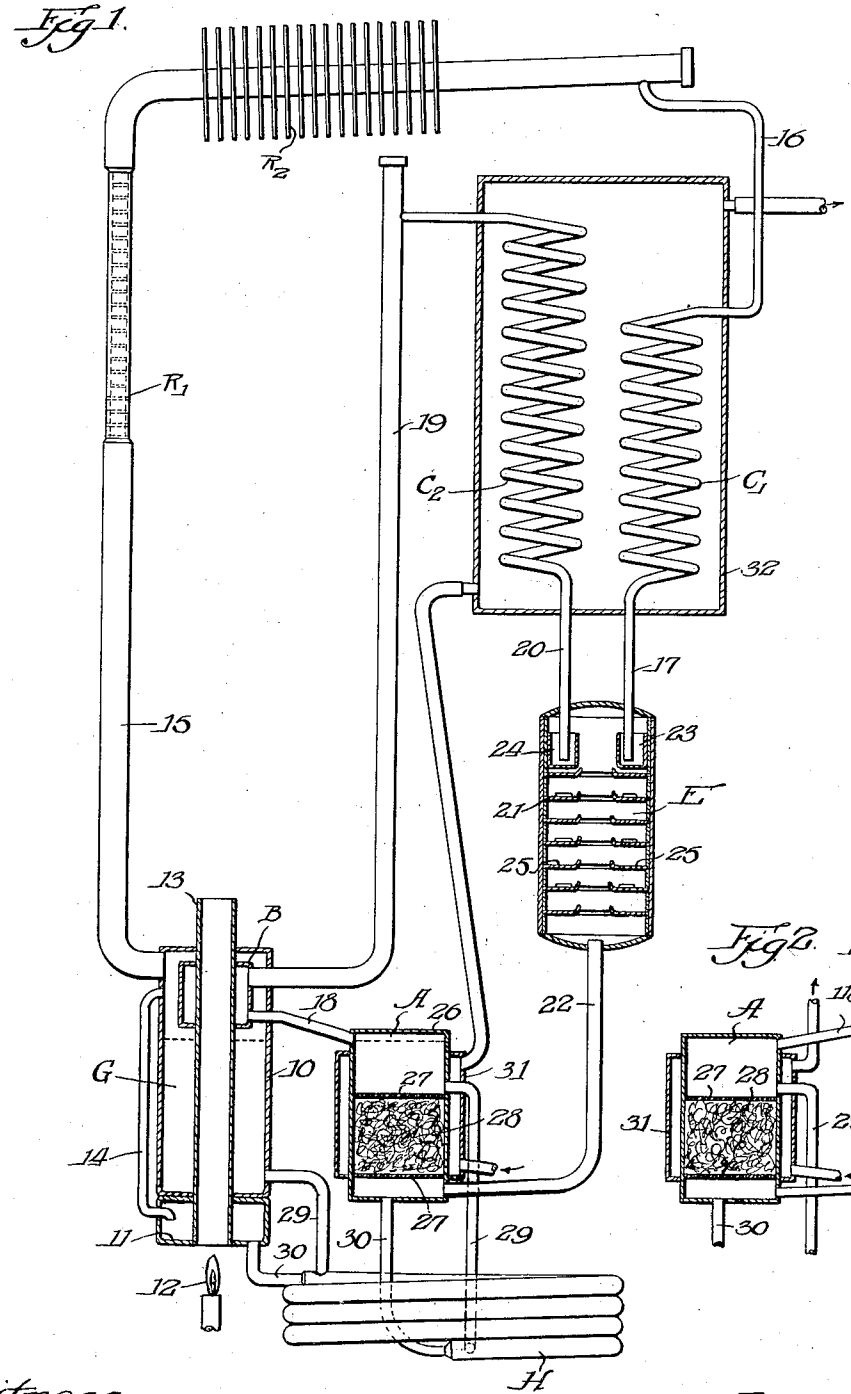



Fig 2.




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# UNITED STATES PATENT OFFICE

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## METHOD OF AND APPARATUS FOR PRODUCING CONTINUOUS REFRIGERATION

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This invention relates to the art of refrigerating and more particularly to continuous absorption refrigerating systems in which the plurality of refrigerants are simultaneously evaporated to produce a cooling effect.

Continuous absorption refrigerating systems employing a single refrigerant in combination with an inert or neutral gas are well known. In such a system the inert gas is circulated between the evaporator and the absorber and in accordance with Dalton's laws of partial pressure maintains the total pressure in these parts the same as that in the other parts of the system although the partial pressure of the refrigerant is lower in the evaporator and the absorber than in the condenser and boiler. An example of such a system is found in the United States patent to Geppert 662,690 of November 27, 1900. As an improvement on this system it has previously been proposed to substitute a second refrigerating agent for the inert gas of the Geppert system so that both the main cooling agent and the auxiliary pressure equalizing agent may be condensed before they are introduced into the evaporator, the object being to increase the efficiency of the system. Perhaps the best substances suggested for this purpose are ammonia and propane, these two refrigerants being condensible at about the same temperature and pressure and being practically immiscible when in their liquid phases.

Now if two refrigerants are to be condensed at one temperature and evaporated, each in the presence of the vapor phase of the other, at a lower temperature to produce a cooling effect, it is clear that they must be effectively separated before they can again be condensed at the higher temperature, provided, of course there is no material difference in the total pressure throughout the system.

One way of separating two gases is effected by causing the mixture of the two to come into contact with a solvent for one of them from which it is later expelled by the application of heat. In the case where ammonia and propane are used, water may be used as a solvent since it readily absorbs the ammonia but not the propane. However, in attempting to separate two refrigerants of a refrigerating machine in this way difficulty has been experienced because of the fact that separation has not been sufficiently complete. Also the refrigerants have been condensed in parts of the apparatus where it is desired and intended that they be in a vapor or gaseous state. For example, in attempting to operate an apparatus heretofore proposed in which an absorber and two condensers were provided, one for ammonia and one for propane, it has been found that the propane is condensed in the absorber instead of in the condenser provided for that purpose. In order to make such a machine operate it is necessary to vaporize the liquefied propane collected in the absorber. Since the propane is much lighter than the ammonia or the ammonia solution it floats on top of the solution in the absorber. By carefully controlling the circulation of the solution, just the right amount of heat may be carried by convection from the heater for the boiler to the absorber to drive off this liquid propane. This requires the use of pipes of certain dimensions and the supply of heat to the boiler must be just right for these requirements. If too much heat is carried to the absorber the solution does not properly absorb the ammonia. If too little is carried thereto the liquid propane is not vaporized.

In order to overcome these and other difficulties, an object of the present invention is to provide for the passage of liquid propane out of the absorber into a separate vessel where the vaporization may be accurately controlled by the application of heat without affecting the ability of the solution in the absorber to absorb the ammonia. In this way the absorber may be maintained at a temperature as low as possible by means of the cooling medium such as air or water, to thus increase the efficiency of the absorption of ammonia while at the same time overcoming the difficulty resulting from the accumulation of liquid propane in the absorber.

A further object is to provide a novel refrigerating system adapted to employ a plurality of refrigerants and in which the two

refrigerants are effectively separated so that they may be easily condensed in their respective condensers.

Further objects reside in the method of producing refrigeration and of effectively separating two refrigerants of such a system.

Other objects and advantages reside in certain novel arrangements and construction of parts which will be apparent in the following description taken in connection with the accompanying drawing, in which:—

Fig. 1 is a diagram of an absorption refrigerating system embodying certain novel features and illustrating one form of apparatus adapted to carry out the principle of the invention and

Fig. 2 is a fragmentary diagrammatic view of the absorber and an auxiliary boiler adapted to be substituted for the similar parts of Fig. 1 and illustrating another form of apparatus adapted to carry out the invention.

Referring to the drawing a system is there shown as consisting of a generator or boiler G, rectifier $R_1$ and $R_2$, condensers $C_1$ and $C_2$, evaporator E, absorber A, heat exchanger H and a small auxiliary boiler B, these vessels being connected by suitable conduits as shown. All of the parts may be made of steel. In general they are cylindrical in shape so that seamless steel tubing may be used in manufacturing them. For purposes of description, it will be assumed that the apparatus is charged with ammonia, propane and water although the invention is not limited to the use of these fluids.

As shown in Fig. 1 the generator G and boiler B are assembled in a unitary construction. The generator G, per se, consists of two chambers or vessels designated by the reference characters 10 and 11 through which a chimney 13 extends. The chimney 13 also extends through the boiler B which is located inside of the vessel 10 and near the top thereof. The vessel 11 located beneath the vessel 10 is connected thereto by a conduit 14 which extends from the vessel 11 to the upper part of the vessel 10, this arrangement constituting one form of gas lift pump for causing the circulation of solution through the main vessel 10 of the generator. Any other known form of gas lift pump such as that shown and described in U. S. patent to Altenkirch 1,728,742 may be used for this purpose. The boiler B is not connected in any way to the vessel 10 but is located inside thereof merely for the purpose of enabling the heat transferred from gases in the chimney 13 thereto. As will appear hereinafter it is important that this boiler be at just the proper height with respect to the normal solution level in the main vessel 10 of the generator G.

The chimney 13 provides convenient means for heating all three vessels, 10, 11 and B, by a single source of heat such as the gas flame 12 shown. If desired, one or more electric cartridge heaters may be placed in the chimney and their positions varied to effect the best heating conditions.

The upper end of the vessel 10 is connected to rectifiers $R_1$ and $R_2$ by means of the conduit 15 which conveys ammonia gas to the rectifiers, the ammonia gas of course having some water vapor therein, a large portion of which is removed by the rectifiers so that practically pure ammonia gas is conveyed through the conduit 16 from the rectifiers into the condenser $C_1$ where it liquefies and flows into the evaporator through the conduit 17.

The function of the auxiliary boiler B is to vaporize liquid propane supplied thereto through the conduit 18 so that practically pure propane gas is conveyed through the conduit 19 into the condenser $C_2$ where it condenses and flows into the evaporator through the conduit 20.

The evaporator E is so constructed that the liquid refrigerants entering through the pipes 17 and 20 do not mix so long as they are in their liquid phases but each liquid is exposed to the vapor phase of the other. For a full disclosure of this evaporator and the manner in which it operates, reference may be had to the copending application of Rudolph S. Nelson, Serial No. 423,125, filed January 24, 1930 for "Evaporators for refrigerating systems". As herein shown it consists of a closed vessel 21 through the top of which the inlet pipes 17 and 20 extend and to the bottom of which the outlet pipe 22 is connected. Inside of the vessel 21 a cup is provided at the lower end of each of the inlet pipes 17 and 20 as shown at 23 and 24. The liquids entering through the inlet pipes overflow from the cups and trickle down over the baffles 25, there being a separate series of baffles beneath each cup. Since the ammonia and propane are maintained separated by this means so long as they are in their liquid phases, the propane does not blanket the ammonia and each refrigerant is exposed to the vapor phase of the other. This causes evaporation of both accompanied by the extraction of heat from the surroundings to produce a cooling effect. Any liquid which may have been supplied to the evaporator and not vaporized is drained away through the gas outlet conduit into the lower portion of the absorber A.

Absorber A consists of a closed vessel 26 provided with perforated plates 27 for holding a quantity of steel wool 28 or the like in the lower central portion thereof. There are two inlet pipes and two outlet pipes connected to the absorber. As mentioned above pipe 22 conveys gases from the evaporator to the lower portion of the absorber while the conduit 18 conveys propane liquid from the

top of the absorber into the auxiliary boiler B. In addition to these conduits, the conduit 29 conveys weak ammonia solution into the upper central portion of the absorber above the perforated plates 27 while the conduit 30 conveys enriched ammonia solutions out of the absorber. The conduits 29 and 30 are connected to the boiler system G through the conventional heat exchanger H.

Both the condenser $C_1$ and $C_2$ and the absorber A should be cooled as effectively as possible by cooling water or air. In the embodiments of the invention shown, this is effected by passing cooling water through the jacket 31 surrounding the absorber and the tank 32 surrounding the condensers.

There are three cycles for fluid circulation provided by this construction. One cycle which may be termed the ammonia cycle takes place from the main vessel 10 of the generator G through the rectifiers $R_1$ and $R_2$, condenser $C_1$, evaporator E, absorber A and conduit 30 back to the lower vessel 11 of the generator G and from there into the vessel 10 to complete its cycle through the conduit 14. Another cycle which may be called the propane cycle takes place from the auxiliary boiler B through the condenser $C_2$, evaporator E, absorber A and conduit 18 back into the auxiliary boiler B to complete its cycle. The third cycle which may be called the solution cycle takes place between the generator and the absorber, the circuit being from the vessel 10 through the conduit 29, into the absorber, the conduit 30 back into the vessel 11 from which it is pumped through the conduit 14 back into the vessel 10, the pumping action being affected merely by the application of heat to the vessel 11 by means of a gas flame electric heater or the like at the lower end of the chimney 13.

The apparatus may be charged and operated as follows:—A quantity of ammonia solution is placed in the generator G and absorber A through suitable valves not shown until the same has filled these vessels up to approximately the level shown by the dotted lines. While it is believed that the machine may be operated with various ammonia concentrations, it is preferable to employ a very low concentration even as low as 15% ammonia by weight. After the solution has been charged into these vessels air may be swept out of the apparatus in the usual manner by forcing ammonia gas into the generator and absorber and permitting the air to escape through a valve in the evaporator or elsewhere in the system. A quantity of liquid propane may then be placed in the system, preferably in the condenser $C_2$ and the conduit 19. The quantity of propane placed in the system should be sufficient to insure the formation of a column of liquid in the pipe 20 and fill the cup 24 and provide for some liquid on the series of baffle plates 25 immediately beneath the cup 24 together with sufficient to fill the auxiliary boiler B and the conduit 18. Placing liquid propane in the auxiliary boiler B will of course lower the solution level in the absorber and raise it in the boiler but since the specific gravity of propane is much less than that of ammonia solution, this difference will not be great and the propane in the boiler B will stand at a higher level than the ammonia solution in vessel 10. The charging valve then being closed and heat supplied to the generator the three cycles for fluid circulation will begin as noted above. A column of liquid propane will form in the conduit 20 and a column of liquid ammonia will form in the conduit 17 and increase the pressure in the evaporator over that of the remainder of the system until the gases formed in the evaporator are forced from it into the lower portion of the absorber through the conduit 22. The condenser $C_1$ and $C_2$ should of course, be located high enough above the evaporator so that the columns which form therein may readily overbalance the column of liquid in the absorber and the auxiliary boiler B. The chief feature of novelty of the present invention resides in the action which takes place in the absorber. As the gases enter the lower portion of the absorber, weak ammonia solution is entering through the conduit 29 into the central portion. The gases pass upwardly through the perforated plates 27 and the steel wool 28 which breaks them up into small bubbles. At the same time the weak ammonia solution is passing downwardly through the plates and the steel wool so that a large portion of the ammonia gas is absorbed, the absorber being maintained as cold as possible by the cooling water in the jacket 31. The gases being deprived of the ammonia content, propane readily condenses and since it is light in weight and immiscible with the absorption solution it rises to the top of the absorber and up into the auxiliary boiler B.

The boiler B should be so positioned with respect to the vessel 10 and absorber A that the proper liquid levels are maintained by natural counterpoise under the influence of gravity upon the liquids. As heat is supplied to the boilers, the circulation of solution will begin so that the level in the vessel 10 will rise slightly above its static position, there being some resistance to flow in the pipe 29. Neglecting this friction head, the column of ammonia solution in the vessel 10 will be balanced by the liquid propane in the boiler B and conduit 18 and the ammonia solution in the absorber. The importance of the relative positions of the vessels 10 and B in order that the proper liquid levels will be maintained therein, is thus apparent.

Should any of the propane or ammonia gases not be absorbed they will also pass into the auxiliary boiler B but if the apparatus

is properly designed and a weak concentration of solution employed, practically all of the ammonia will be absorbed and all of the propane condensed in the absorber so that effective separation may be obtained by gravity action on the two liquids and the only ammonia which is carried into the boiler B is that which has been dissolved in the liquid propane,—a negligible quantity.

The ammonia which is absorbed in the solution in the absorber is conducted through the pipe 30 into the boiler system from which it is again expelled and conveyed as a gas into the condenser $C_1$ as described above. At the same time the propane is vaporized in its boiler B and conveyed to the condenser $C_2$ where it is again condensed. It will thus be seen that a refrigerating system has been provided in which two refrigerants are simultaneously evaporated and are then separated so that they may be condensed in their respective condensers and at the same time only one absorption solution is used and no moving parts are necessary.

In the embodiment shown in Fig. 2, the parts corresponding to those of Fig. 1 are similarly marked. The only difference between the structure here indicated and that of Fig. 1 resides in the fact that the auxiliary boiler B for the propane is not located within the vessel 10 of the main generator but is located off to the right of the absorber A and is provided with an independent source of heat so that it can be maintained in any desired temperature with respect to the temperature in the main generator. As shown in this figure the heating means may consist of a small gas flame indicated by the reference character 35 while the conduit connecting the auxiliary boiler B to the absorber is designated 118 and the vessel itself by the reference character 112. The vessel 112 should of course be located at the same relative height with respect to the absorber and main generator as in Fig. 1 and the operation is practically identical.

Since the drawing is only diagrammatic in nature, it is of course obvious that other changes than those indicated, may be made, and various expedients resorted to without departing from the spirit of the invention or the scope of the annexed claims. The vessels may be made of different shapes and dimensions so long as they do not interfere with the intended circulation and liquid levels. For example, it is within the purview of the invention to form the chamber 12 of Figure 1 by suitable partitions in the chamber 10 rather than the construction shown. It is also within the scope of the invention to regulate the flow of fluids in any of the various circuits by the provision of valves or restricted portions or the like although if the apparatus is properly designed these will not be necessary.

I claim:—

1. In refrigerating apparatus adapted to produce cooling effect by the simultaneous evaporation of two refrigerants, absorption means wherein both refrigerants may be changed from gaseous phases to more dense phases and separated by gravity action upon them, a boiler for each refrigerant, means for conducting the refrigerants from said absorption means to their respective boilers and a single source of heat for vaporizing both refrigerants in their respective boilers.

2. In refrigerating apparatus adapted to produce cooling effect by the simultaneous evaporation of two refrigerants, absorption means wherein both refrigerants may be changed from gaseous phases to more dense phases and separated by gravity action upon them, a boiler for each refrigerant, means for conducting the refrigerants from said absorption means to their respective boilers and means for heating said boilers including a single chimney passing through both of said boilers.

3. In refrigerating apparatus adapted to produce cooling effect by the simultaneous evaporation of two refrigerants, the combination of absorption means wherein both refrigerants may be changed from gaseous phases to more dense phases and separated by gravity action upon them, two boilers, one for each refrigerant and one of said boilers being located within the other and conduits for conveying the refrigerants from said absorption means to said boilers.

4. In refrigerating apparatus adapted to produce cooling effect by the simultaneous evaporation of two refrigerants, the combination of absorption means wherein both refrigerants may be changed from gaseous phases to more dense phases and separated by gravity action upon them, two boilers, one for each refrigerant, conduits for conveying the refrigerants from said absorption means to said boilers and a single chimney associated with both of said boilers.

5. In absorption refrigerating apparatus adapted to contain three fluids consisting of two immiscible refrigerants of different specific gravity and a solvent for one of them, the combination of an absorber wherein one refrigerant may be absorbed and the other condensed, two boilers, one for each of said refrigerants and conduits connecting said absorber and said boilers to maintain the liquids therein at predetermined relative levels by permitting them to counterbalance one another.

6. In absorption refrigerating apparatus adapted to contain three fluids consisting of two immiscible refrigerants of different specific gravity and a solvent for one of them, the combination of an absorber wherein one refrigerant may be absorbed by said solvent

and the other condensed, two boilers, one for each of said refrigerants, interconnected with said absorber and adapted to contain said fluids in counterpoised positions.

7. In absorption refrigerating apparatus, in combination, a main refrigerant, an auxiliary refrigerant having a specific gravity different from that of the main refrigerant, a solvent for said main refrigerant, an absorber wherein the main refrigerant may be absorbed in the solvent and the auxiliary refrigerant condensed, a main boiler for the main refrigerant, an auxiliary boiler for the auxiliary refrigerant and conduits connecting said absorber and said boilers to maintain the liquids therein counterpoised.

8. In refrigerating apparatus, the combination of an absorber, a main boiler, means for supplying a gaseous mixture of two refrigerants to said absorber, means for circulating a solvent for one of said refrigerants between said absorber and said main boiler to thereby cause both refrigerants to change to more dense phases by absorbing one and causing the other to condense, an auxiliary boiler and means for conveying the condensed refrigerant to said auxiliary boiler.

9. In refrigerating apparatus the combination of an absorber, a main boiler, means for supplying a gaseous mixture of ammonia and propane to said absorber, means for circulating a solution of ammonia between said absorber and said main boiler to absorb the gaseous ammonia supplied to the absorber and thereby cause the propane supplied to the absorber to condense therein and separate from the solution under the influence of gravity action, an auxiliary boiler and means for conveying the condensed propane to said auxiliary boiler.

10. The method of producing continuous refrigeration which includes the steps of simultaneously evaporating two refrigerants in the presence of each other to produce a cooling effect, conveying the refrigerants so vaporized into a vessel containing a solvent for one of them to thereby cause one to be absorbed and the other to condense, separating the refrigerants under the influence of gravity after they have been so changed, conveying the separated refrigerants out of said vessel, heating the refrigerants to again vaporize the same, separately condensing the refrigerants and returning them into the presence of each other to start the cycle anew.

11. In refrigerating apparatus adapted to produce cooling effect by the simultaneous evaporation of two refrigerants, absorption means for causing one refrigerant to be absorbed in an absorption liquid and the other refrigerant to condense, a boiler for each refrigerant and means for separating the refrigerant absorbed in said absorption means from the refrigerant condensed therein and for conveying the refrigerants to their respective boilers.

Signed at Chicago, in the county of Cook and State of Illinois, this 26th day of June, A. D. 1930.

EARL BABCOCK.